EMC Test Plan for Shipboard In-Harbor and At-Sea Measurements for L-Band Terminal

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prepared for

National Aeronautics and Space Administration

Goddard Space Flight Center

Greenbelt, Maryland

Submitted: 12 June 1974

Government Services Operations

RCA Service Corporation

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1.0 Introduction

1.1 Objective of Plan

The objective of this test plan is to provide a test procedure for the measurement of on-board radio frequency interference resulting from the operation of on-board radars (S-Band and X-Band). Field intensity measurements in the range of 1 to 10 GHz will be made using calibrated test instrumentation to determine possible adverse effects to the operation of the future installation of a Maritime L-Band Shipboard Satellite Communications Terminal, for use with the ATS-F and MARISAT Communications Satellites. A measurement will be made of power line conducted interference to determine the degree of power line isolation that may be required. There is also consideration of interference to the radars by the proposed L-Band terminals and observations will be made of the radar displays while L-Band transmitter operation is simulated. These tests will be made aboard the *American Alliance container ship, United States Lines.

This effort is in direct support of the Maritime Administration, U.S. Department of Commerce. Both dock-side and at-sea measurements are required.

1.2 Tasks to be Performed

The tasks to be performed have been organized into the

*American Leader Class, Type C6 (15,690 tons) following categories:

(1) Measurement of Electromagnetic Interference (EMI) levels within the L-Band (1,535 to 1,660 GHz) shipboard, 4 foot antenna terminal equipment using Electromagnetic Compatibility (EMC) test equipment. The effectiveness of EMC rejection filters will be determined.

(2) Effect of L-Band emission (1.659 GHz) from 4 foot shipboard terminal antenna upon operation of on-board S-Band and X-Band radars.

(3) Field Intensity Measurements over 1 to 10 GHz frequency range using calibrated EMC test equipment. Measurements will be made on the Flying Bridge, on the Radar Mast and in the Storage Room where S-Band and X-Band transmitters are located.

(4) Antenna sky-noise temperature measurements at the output terminals of the 4 foot dish antenna (centered at 1559 MHz).

(5) Conducted interference measurements in the frequency range of 150 kHz to 32 MHz on the power lines serving the storage room.

1.2.1 L-Band Interference Level and Filter Performance

These measurements will be made to determine the filtering filtering action of the antenna feed, diplexer, LNA, and special band rejection filters individually and in combination.

Measurements will be made with the 4 foot dish antenna at each of the following locations:

(1) Flying Bridge, Center. A platform will be erected on the flying bridge below the radar platform.

(2) Flying Bridge, Port Side. The platform will be moved to the port side of the flying bridge.

(3) Flying Bridge, Starboard Side. The platform will be moved to the starboard side of the flying bridge.

1.2.2 Interference of Radar Observations

Interference of the proposed L-Band terminal to the S-Band and X-Band radars is also of concern and will be investigated by radiating an L-Band signal from the 4 foot dish antenna. A 1.6 GHz, 15 watt power oscillator will be connected to the transmitter port of the diplexer. The radar displays will be monitored for interference when the 4 foot dish antenna is rotated through 360 degrees in azimuth for various elevation angles.

1.2.3 Field Intensity Measurements

It is planned to make field intensity measurements at a number of locations on shipboard;

(1) Flying Bridge, Center. A platform will be erected on the flying bridge below the radar platform.

(2) Flying Bridge, Port Side. The platform will be shifted to the port side of the flying bridge.

(3) Flying Bridge, Starboard Side. The platform will be shifted to the starboard side of the flying bridge.

(4) Aft of Radar Platform. An antenna will be cantilevered out directly aft of the radar platform.

(5) Starboard of Radar Platform. The antenna will be swung around to the starboard side of the radar platform.

(6) Storage Room. Measurements will be made near the S-Band and X-Band radar cabinets.

These field intensity measurements can be resolved into two categories, for L-Band (a) in-band, 1.530 to 1.660 GHz, and (b) out-of-band, 1 to 10 GHz.

1.2.4 Antenna Sky Noise Temperature Measurements

Antenna sky noise temperature measurements will be made using a prototype, L-Band 4 foot parabolic dish antenna, diplexer, low-noise amplifier (LNA) and down converter tuned to the ATS-F frequency of 1.559 GHz. The measurements will be made with the 4 foot dish antenna mounted in three locations on the flying bridge deck as shown in Figure 1. The antenna stand shown in Figure 2 will be used to raise the antenna above nearby obstructions. The antenna tripod allows adjustment of the antenna in elevation and azimuth and degree scales are provided for each adjustment.

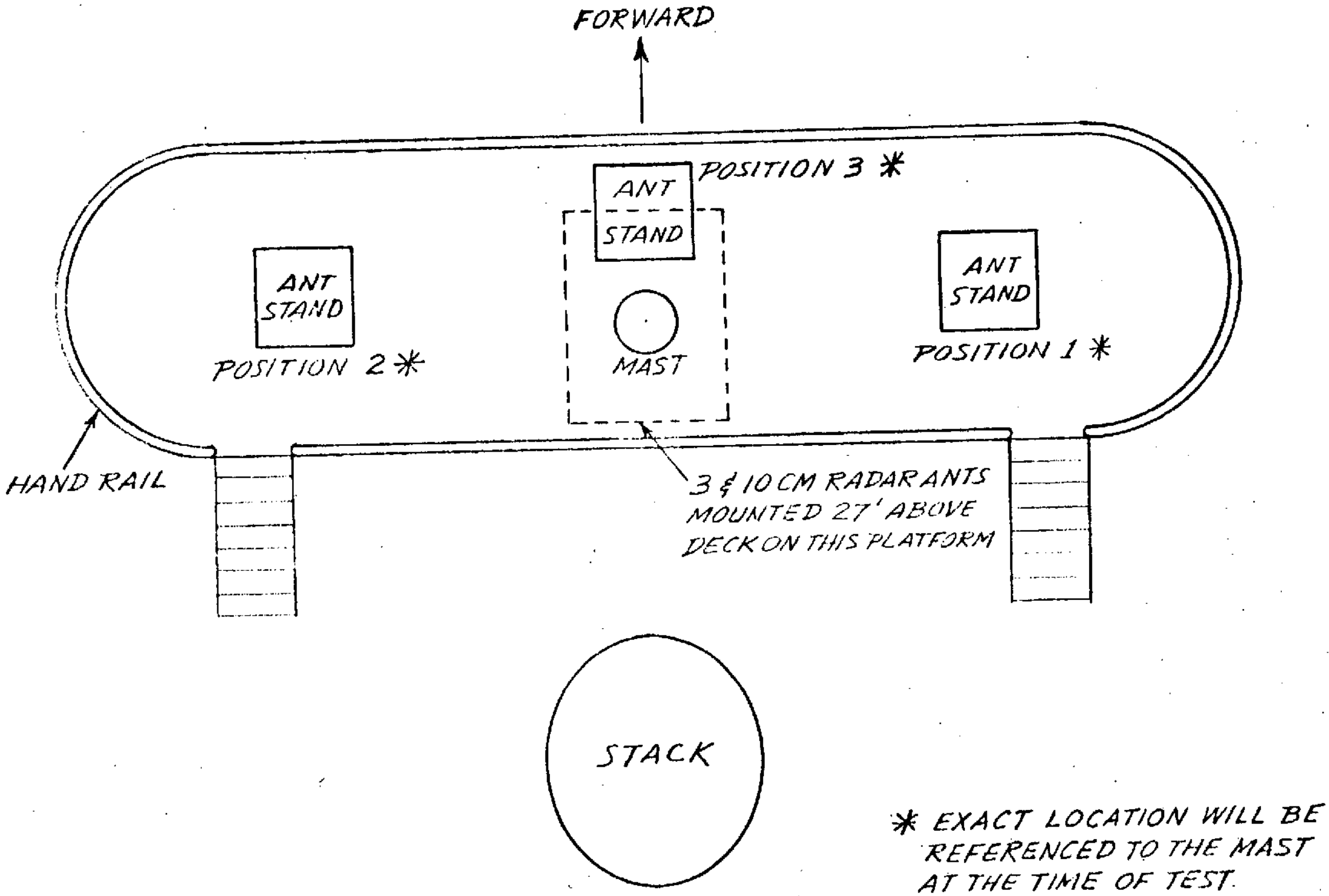

FIGURE 1
TOP VIEW OF FLYING BRIDGE AND LOCATION OF ANTENNA STAND

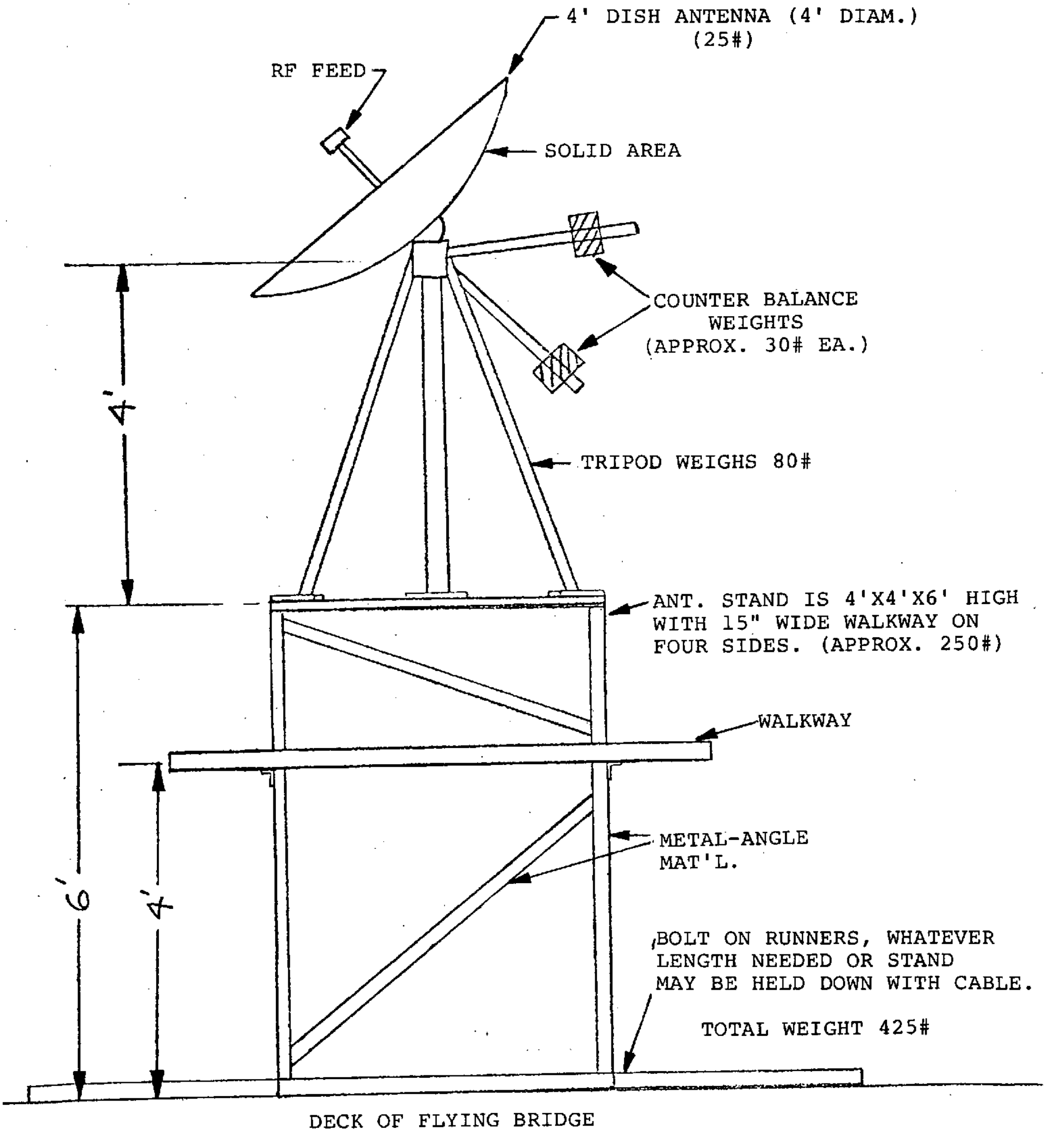

FIGURE 2 - ANTENNA STAND FOR TRIPOD AND DISH

The antenna will be rotated in azimuth through 360° while the elevation is set in 5° increments from 5° to 50° and in 10° increments from 50° to 90°.

Antenna sky noise temperature measurements will be made with a Dicke radiometer, AIL type 2392A. A cold load temperature reference using liquid Nitrogen (77^{O}-80^{O}K) will be used. Antenna noise temperature resolution will be better than one degree Kelvin.

1.2.5 Conducted Intererence Measurements

Conducted emission measurements are planned on the power lines which serve the storage room. These power lines serve the two radar sets and will also exhibit interference effects from other types of equipment connected to the ship's power system.

1.3 Priority List, Order of Performance

	Harbor	At-Sea
Radar Interference, within L-Band shipboard terminal equipment		
Flying Bridge, Port	2	2
Center	1	1
Starboard	2	2
L-Band Terminal Interference with on-board radar observations		
Flying Bridge, Port	3	3
Center	3	3
Starboard	3	3

		Harbor	At-Sea
Radar Interference, Field Intensity Measurements			
Flying Bridge,	Port	5	5
	Center	4	4
	Starboard	5	5
Radar Mast,	Aft	9	9
	Starboard	7	7
Storage Room		8	N/A
Antenna Sky Noise Temperature Measurements			
Flying Bridge,	Port	N/A	7
	Center	N/A	6
	Starboard	N/A	7
Conducted Interference Measurements			
Storage Room		6	10

2.0 Quality Assurance

2.1 Certification of Instruments

Instruments used for this test will be within manufacturers tolerances for amplitude and frequency. A sticker to this effect will be placed on the front panel of each instrument. Where calibration by substitution is employed, the sticker need appear on the calibration standard only.

2.3 Pre-Calibration

Pre-Calibration of interference receivers will be used for broadband measurements of radiated and conducted interference. Pre-calibration will also be used for measurement of discrete CW signals.

3.0 Test Locations

3.1 Harbor Test

Measurements will be made while the ship is docked in New York harbor and if there is insufficient time to complete these measurements before leaving the harbor the measurement schedule will be continued in each harbor the ship visits until it is ready to depart for a foreign port. A priority listing has been assigned to each measurement in the event that there is insufficient time in the harbors to complete the entire set of measurements.

The harbor measurements will probably show a more severe operating environment for the L-Band terminal than the at-sea measurements. All types of land-based communications-electronics equipment plus incidental radiation devices including automobile ignition systems will contribute to the harbor electromagnetic environment.

Conducted interference measurements on the ship's power lines will not be influenced by interference sources external to the ship. However, the harbor measurements may show interference from certain types of machinery and equipment that will only be exercised while the ship is loading and unloading.

The complete set of measurements described in section 1.2 will be made insofar as time allows in the various harbors the ship will visit before departing for a foreign port.

3.2 At-Sea Test

The at-sea measurements will be made while the ship is under way between east coast ports. It is the intention that these measurements will determine the electromagnetic environment of the proposed L-Band terminal while away from the influence of land-based interference sources. Consequently, these measurements will only be run while the ship is at least 10 miles from the shore.

All of the measurements scheduled for the harbor, except the field intensity measurements in the storage room, will be repeated at sea. There may not be sufficient time to complete all of these measurements so a priority list has been drawn up to assure that measurements will be made in order of importance.

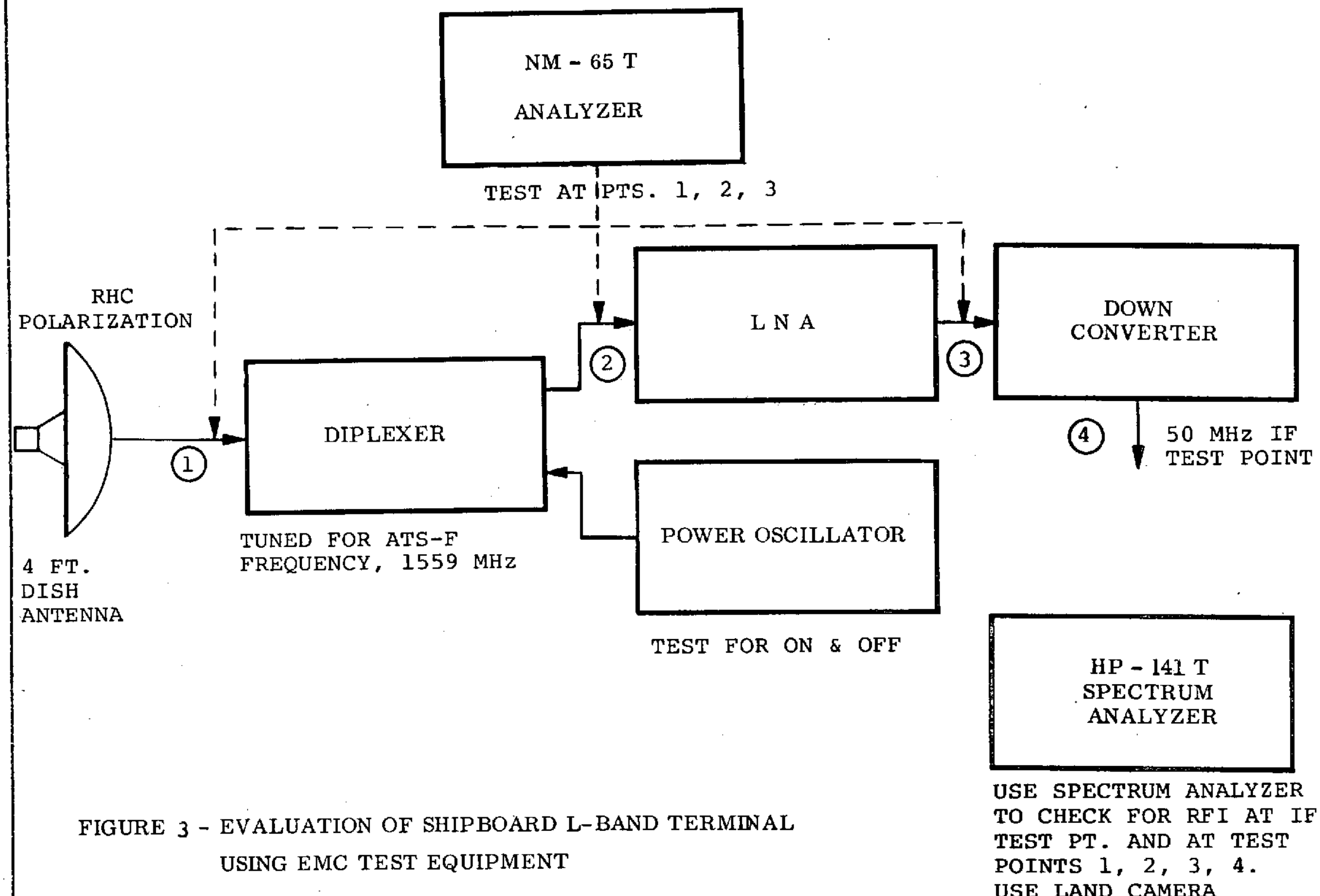

FIGURE 3 - EVALUATION OF SHIPBOARD L-BAND TERMINAL
USING EMC TEST EQUIPMENT

4.0 TEST PROCEDURE

4.1 TEST SETUP

4.1.1 EVALUATION OF SHIPBOARD L-BAND TERMINAL AND REJECTION FILTERS (50MHz to 10GHz)

The evaluation of the shipboard L-band terminal and the rejection filters will be made with the L-band terminal 4 foot dish antenna located in each of the three positions on the flying brdige shown in Figure 1. The evaluation will be made in three phases. Phase One will measure inband interference (1.535 to 1.660 GHz) and out-of-band interference (1.0 to 10.0 GHz) using the NM-65T Radio Interference Analyzer at test points as shown in Figure 3. Phase Two will use the HP-141T Sepctrum Analyzer to look at interference signals at the test points indicated in Figure 3. The Spectrum Analyzer will be adjusted to show a frequency range of 0 to 100 MHz to look for possible interfering signals at the intermediate frequency of 50 MHz and in the range of 0 to 10 GHz to look for other possible interfering signals. Phase Three will evaluate the performance of the three rejection filters which will be inserted in the three locations in the L-band terminal system as shown in Figure 4a through 4c. The effect of the transmitter filter will be observed on the display of the S-band and X-band radars. The effect of the filter ahead of the diplexer and ahead of the LNA will be evaluated with the HP-141T Sepctrum Analyzer connected to the test points shown in Figure 4a through 4c.

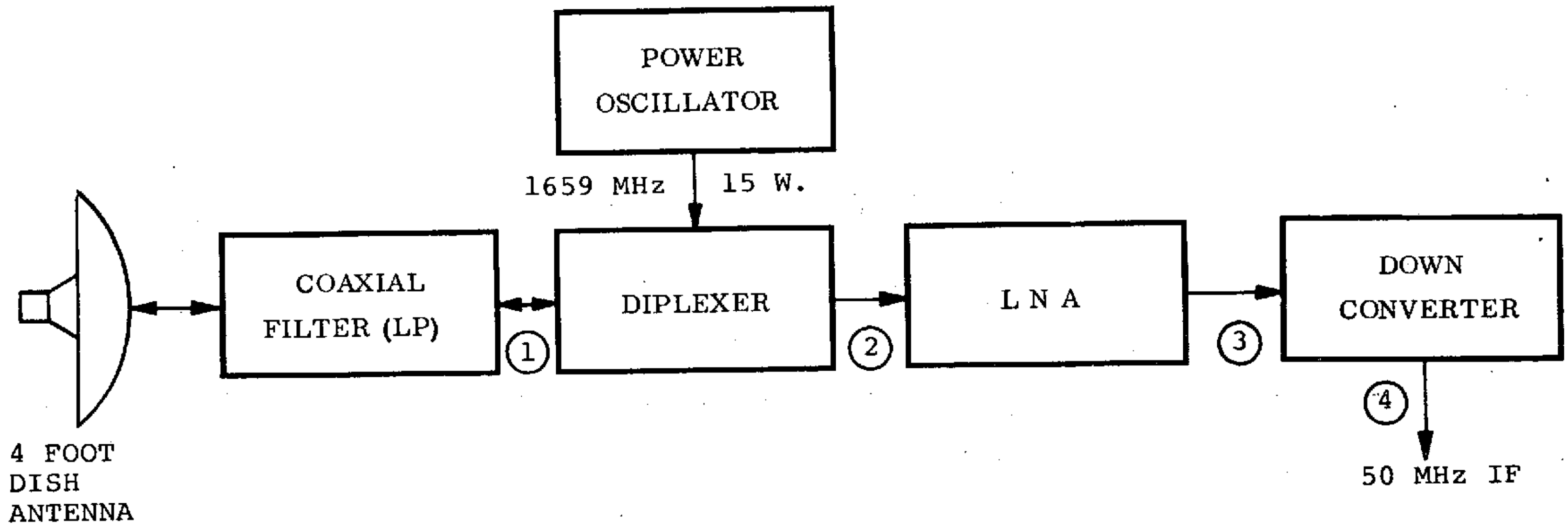

FIGURE 4a-EVALUATION OF REJECTION FILTERS, LP FILTER AHEAD OF DIPLEXER

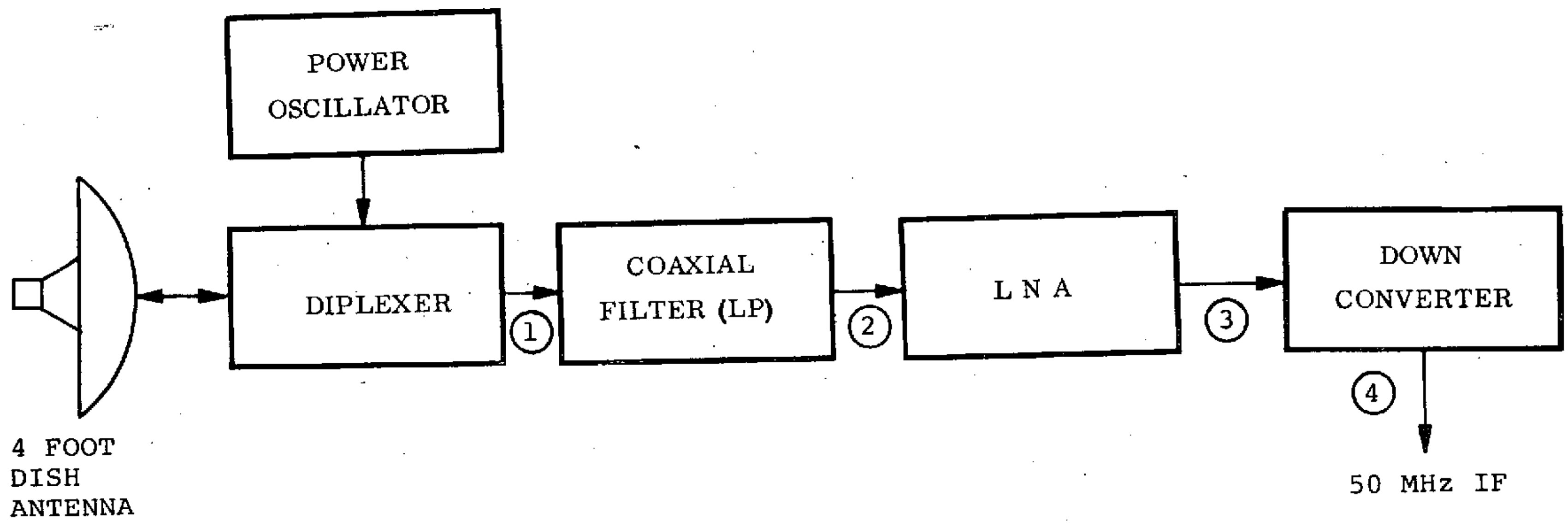

FIGURE 4b - EVALUATION OF REJECTION FILTERS, LP FILTER AHEAD OF LNA

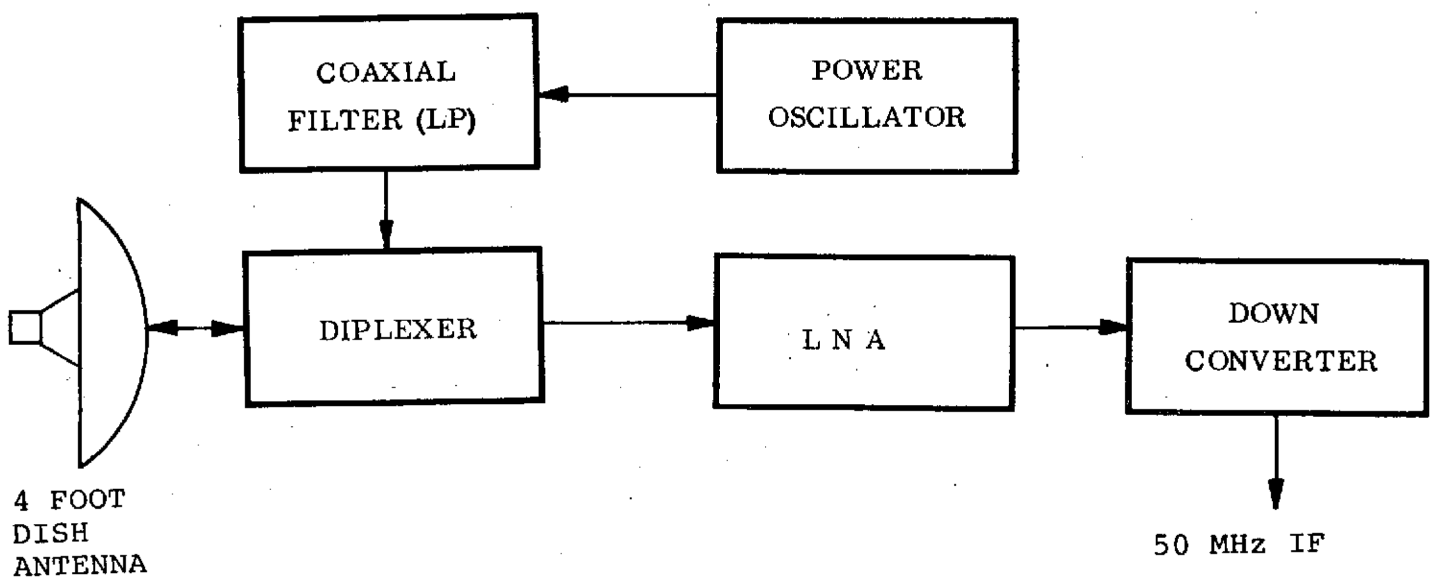

FIGURE 4c - EVALUATION OF REJECTION FILTERS, LP FILTER AHEAD OF TRANSMITTER

4.1.2 INTERFERENCE TO RADAR OBSERVATIONS (1.659 GHz)

The interference to radar observations will be made with the 4 foot dish antenna in each of the same three positions on the Flying Bridge that were used for the antenna sky-noise temperature measurements. The instrumentation setup is shown in Figure 5. An AIL power oscillator tuned to 1.659 GHz and with and output of 15 watts is connected to the diplexer transmitter port to radiate through antenna.

4.1.3 FIELD INTENSITY MEASUREMENTS (1.0 to 10 GHz)

The locations for above deck field intensity measurements are shown in Figure 1 for flying bridge locations and Figure 6 for radar mast locations. Below deck measurements will be made in the storage room at a distance of one meter in front of each radar transmitter cabinet. A broadband log periodic spiral conical antenna will be used. This antenna is designed for field intensity measurements over the range of 1 to 10 GHz. In-band measurement will be made using a standard gain horn antenna.

4.1.4 ANTENNA SKY NOISE TEMPERATURE MEASUREMENTS (1.559 GHz)

The antenna sky noise temperature measurements will be made with the 4 foot dish antenna mounted on the TACO tripod which in turn will be mounted on the structural steel platform as shown in Figure 2. Measurements will be made in each of three positions on the flying bridge as shown in Figure 1.

Reference to Figure 7 shows a block diagram of the instrumentation set up. The radiometer is fed by the L-band down converter which in turn is fed by the low noise amplifier (LNA). A coaxial switch selected either the reference hot load, the reference cold load, or the diplexer and antenna as an input to the LNA.

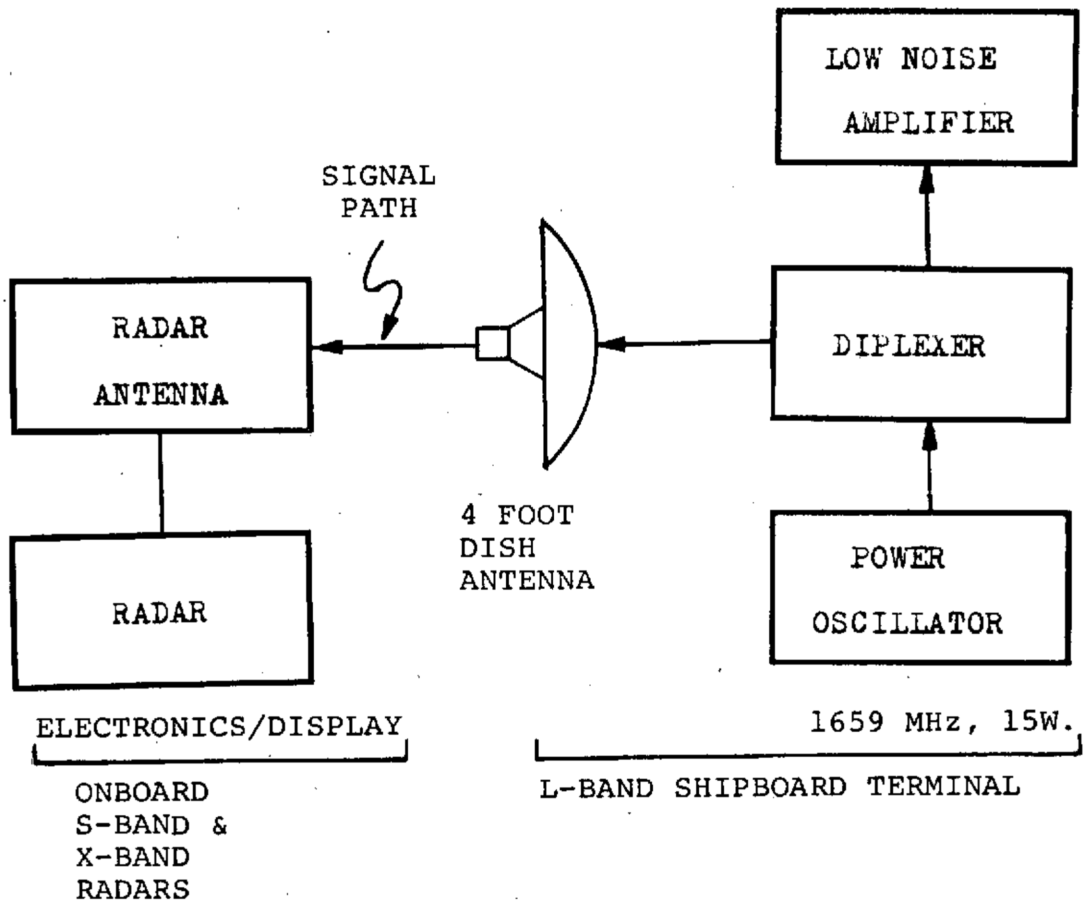

FIGURE 5 - RADAR INTERFERENCE SETUP TO DETERMINE EFFECT OF SHIPBOARD TERMINAL TRANSMITTER

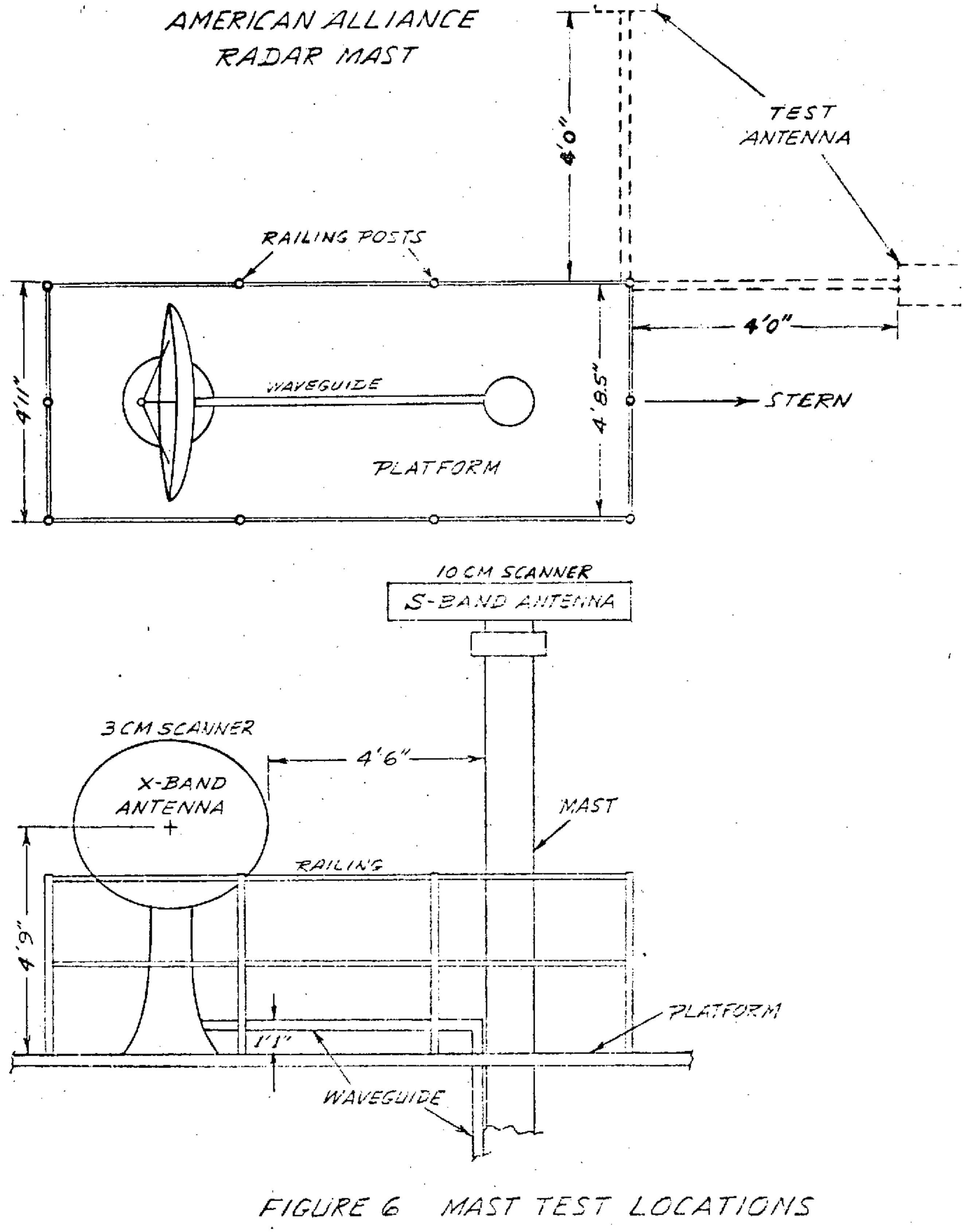

FIGURE 6 MAST TEST LOCATIONS

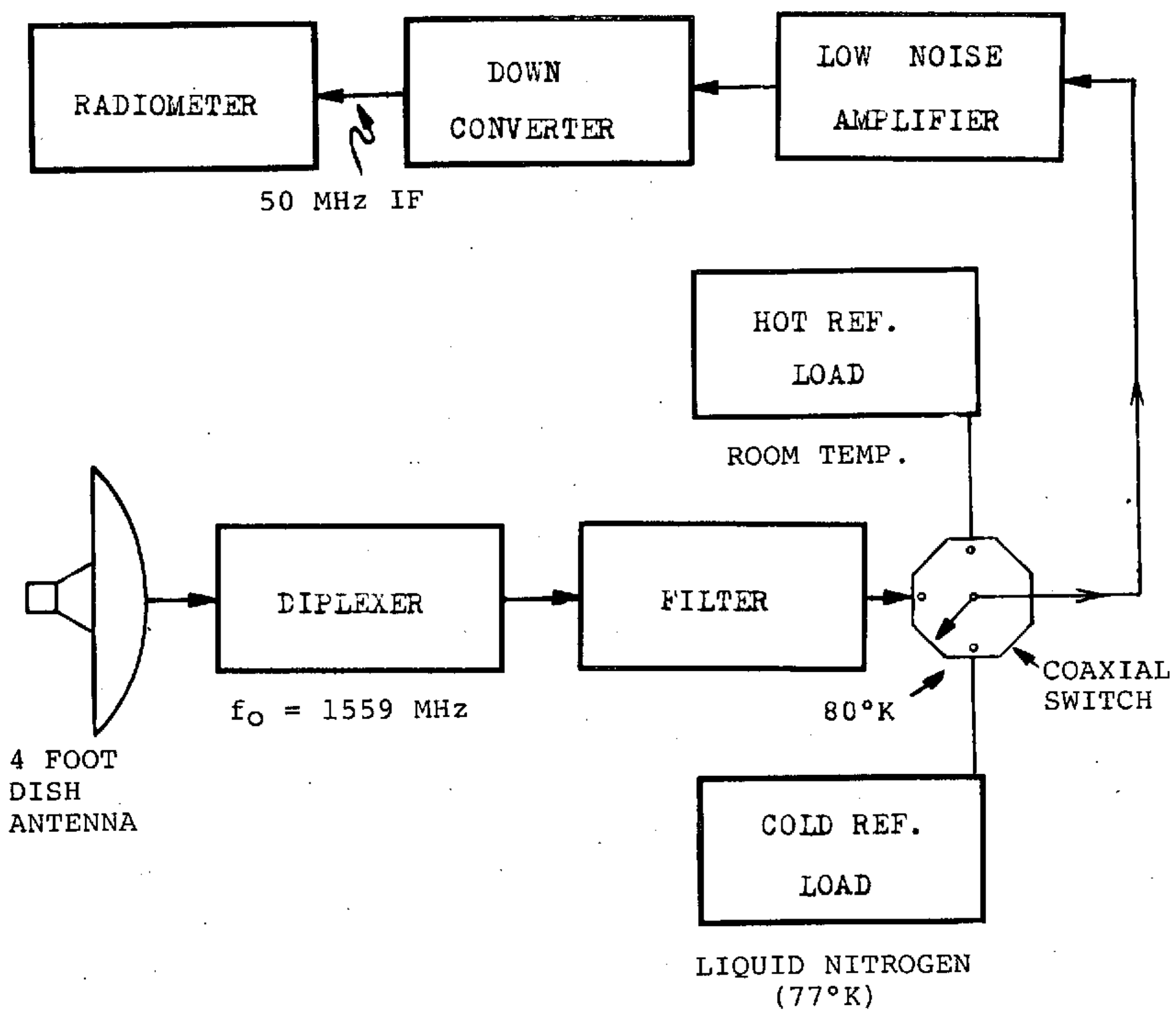

FIGURE 7 - RADIOMETER INSTRUMENTATION FOR ANTENNA SKY-NOISE MEASUREMENT

4.1.5 CONDUCTED INTERFERENCE MEASUREMENTS (150 kHz to 32 MHz and 70 MHz)

Conducted interference measurements will be made on power line circuits in the storage room. The front panel of the electrical power distribution box will be removed to provide access to wires with the current probe. An X-Y recorder plot will be run for the 150 kHz to 32 MHz portion of the spectrum. The Spectrum Analyzer will be used to investigate the spectrum in the vicinity of 70 MHz.

4.2 Operating Procedure

4.2.1 Evaluation of Shipboard L-Band Terminal and Rejection Filters (0 to 10 GHz)

4.2.1.1 Phase One - Evaluation Using Radio Interference Analyzer (1.0 to 10.0 GHz)

In this test the NM-65T Radio Interference Analyzer will be used to measure inband interference in the frequency range of 1.535 to 1.660 GHz at the output of the 4 foot dish antenna feed, the receiver port of the diplexer and at the output of the LNA. Out-of-band measurements will be made in the frequency range of 1 to 10 GHz at the same three test points. Data will be recorded by the X-Y recorder connected to the NM-65T. Figure shows the setup in block diagram form. The measurement procedure follows:

1. Adjust the X-Y recorder controls so that 1 GHz is at the left index of the graph grid and 10 GHz is at the right index.

2. Measurements will be made with the Bandwidth Control set at 5 MHz and the Function Switch set at Direct Peak.

3. With the Attenuator set at CAL adjust the CAL control for internal calibration.

4. Set the Attenuator to the X1 range and tune through the 1.535 to 1.660 GHz frequency range with the X-Y recorder running.

5. If there are signals which exceed full scale make additional runs with the attenuator set at successively higher steps until all signals are within the scale range.

6. Repeat this procedure for out-of-band measurements expanding the tuning range to 1 to 10 GHz.

7. Repeat the in-band and out-of-band measurements at each of the proposed L-band locations on the flying bridge.

4.2.1.2 Phase Two - Evaluation of L-Band Terminal Using Spectrum Analyzer (1 to 10 GHz)

In this test the Hewlett-Packard 141T Spectrum Analyzer will be used to look at the inband interference in the frequency range of 1.535 to 1.660 GHz at three test points: at the output of the 4 foot dish antenna, the receiver port of the diplexer, and the output of the LNA. Out-of-band measurements in the frequency range of 1 to 10 GHz will be made at the same three test points. At a fourth test point, the output of the down converter, the frequency range of 0 to 100 MHz will be observed. Data will be recorded on Polaroid film with a scope camera attached to the HP-141T display. Figure 3 shows the test setup in block diagram form. The measurement procedure follows:

1. Adjust the HP-141T Bandwidth Control to 100 KHz, the Scan Width Control to 100 kHz/div. and the attenuator to a position which will give an on-scale display.

2. With the S-band and X-band radars in operation connect the HP-141T to each of the test points 1, 2, and 3 shown in Figure 3.

3. Make a Polaroid photograph of the HP-141T display at each test point.

4. Adjust the HP-141T Scan Width Control to 10 MHz/div. and the center frequency to 50 MHz.

5. Connect the HP-141T to test point 4 and make a Polaroid photograph.

4.2.1.3 Phase Three - Evaluation of Rejection Filters

The evaluation of the three rejection filters will be made with the NM-65T Radio Interference Analyzer, the HP-141T Spectrum Analyzer and by observation of the S-band and X-band radar displays. One of the filters is used between the antenna and diplexer, one in the receiver section and one in the transmitter section of the L-band terminal. The evaluation of the antenna-diplexer filter and the receiver filter will be made with the S-band and X-band radars operating to provide the interference signals. The transmitter filter will be evaluated while the power oscillator simulates the L-band terminal transmitter and possible interference is observed on the S-band and X-band radar displays. The X-Y recorder will be connected to the NM-65T to record the radar interference with and without the filter in the antenna-diplexer circuit and with and without the filter in the receiver circuit. At the same time the oscilloscope camera will be used to record the filter effect with the HP-141T. The test points are shown in Figure 4. When the filter-in and filter-out comparison is made for the transmitter circuit a photograph or sketch will be made of the S-band and X-band radar displays. The measurement procedure follows:

1. Adjust the X-Y recorder controls so that 1.535 GHz is at the left index of the graph grid and 1.660 GHz is at the right hand index.

2. Measurements will be made with the NM-65T Bandwidth Control set at 5 MHz and the Function Switch set at Direct Peak.

3. With the Attenuator set at CAL adjust the CAL control for internal calibration.

4. Set the Attenuator to the range that will record signals without exceeding full scale.

5. Connect the NM-65T to test point 1.

6. Tune through the frequency range with the radars on and the antenna-diplexer filter out of the circuit and again with the filter installed. Both runs will be recorded on the same graph chart.

7. Repeat this procedure at test point 2.

8. Repeat this procedure at test point 3.

9. Adjust the HP-141T to display the frequency range of 0 to 100 MHz.

10. Connect the HP-141T to the output of the Down Converter.

11. With the S-band and X-band radars operating make a Polaroid photograph of the HP-141T display.

12. Insert the rejection filter in the antenna-diplexer circuit and make a Polaroid photograph of the HP-141T display.

13. Repeat the above procedure using the NM-65T and the HP-141T to evaluate the receiver circuit rejection filter.

14. Set up the AIL Power Oscillator connected to the diplexer transmitter port and adjust the frequency to 1.659 GHz with full power output of a nominal 15 watts.

15. Observe the S-band and X-band radar displays for interference. Make sketches or photographs of interference shown on the displays.

16. Insert the transmitter rejection filter between the AIL Power Oscillator and the diplexer transmitter port.

17. Observe the S-band and X-band radar displays for interference. Make sketches or photographs of interference shown on displays.

4.2.2 Interference to Radar

The observations will be made using the AIL Model 124 Power Oscillator adjusted to the L-band terminal transmit frequency of 1.659 GHz. The power oscillator will be fed into the transmitter port of the diplexer so that its output will be radiated from the 4 foot diameter L-band antenna. The procedure is as follows:

1. Adjust the power oscillator to the L-band Frequency, 1659 GHz, and adjust the power output to maximum (15 watts, nominal).

2. Point the antenna at the S-band radar and observe the radar display for possible interference.

3. Photograph radar display or make sketch of display.

4. Reduce power oscillator output until interference disappears and record power output level.

5. Repeat this procedure for the X-band radar.

6. Check for the presence or absence of RF bandpass filters in the waveguide of the S-band and X-band radars. Annotate same on data sheet.

4.2.3 <u>Field Intensity Measurements</u>

The field intensity measurements will be made with the Singer Stoddart, Model NM-65T Radio Interference Analyzer Receiver using standard horn antennas and the Conical Spiral antenna as a broadband antenna. The in-band measurements will be made using the L-band horn antenna and the 1 to 10 GHz band (out-of-band) measurements will use the conical log spiral antenna. The X-Y recorder will be connected to the X and Y outputs of the NM-65T. Either AC line power or self contained battery power will be used to operate the NM-65T. The measurement procedure follows:

1. Adjust the X-Y recorder controls so the 1 GHz is at the left index of the graph grid and 10 GHz is at the right index.

2. Measurements will be made with the Bandwidth Control set at 5 MHz and the Function Switch set at Direct Peak.

3. With the Attenuator set at CAL adjust the CAL control for internal calibration.

4. Set the Attenuator to the X1 range and tune through the 1 to 10 GHz range with the X-Y recorder running.

5. If there are signals which exceed full scale make additional runs with the attenuator set at successively higher steps until all signals are within the scale range.

6. Repeat this procedure for in-band measurements but limit the tuning range to 1535 to 1660 MHz using the L-band horn antenna.

4.2.4 Antenna Sky-Noise Temperature Measurement Procedure

The purpose of this test is to determine the noise temperature of the overall integrated antenna-feed-receiver system in the presence of atmosphere and surface-produced noise contributions.

All sky-noise temperature measurements will be referenced to the antenna output terminals. A block diagram test setup is shown in Figure 7. The noise source is selected with the coaxial switch and can be the hot or cold reference or the antenna through the diplexer.

The cold load is a liquid nitrogen load cooled to 77 degrees K with the small loss in the coaxial line the reference temperature becomes 80 degrees K. The hot load is at ambient temperature measured with a thermometer attached to the load. The noise sources are alternately connected to the LNA through a coaxial switch. The output of the LNA is fed to the L-band down converter which is turn is connected to the radiometer. In making a measurement the radiometer attenuator is adjusted to a balance with the cold load and again with the hot load, the readings being recorded on the data sheet. The antenna is then switched in to the amplifier and a third balance is made and the attenuator settings recorded.

4.2.5 Conducted Interference Measurements

The conducted interference measurements will be made with the Singer Stoddart NM-25T Radio Interference Field Intensity Analyzer using the Part No. 91550-1 Current Probe as an input device to measure interference currents on the power lines. Headphones will be used to monitor the audible output of the NM-25T so that the type of interference can be described. The measurement procedure follows:

1. With the Function Switch set at CAL, adjust the CAL control for internal calibration.

2. Clamp the current probe around one of the lines to be measured. Lines will be identified according to load.

3. Set the Function Switch to QP (quasi peak) and the Attenuator to -20dB or to a setting giving on-scale meter readings.

4. Tune the NM-25T from 150 kHz to 32 MHz and record on the data sheet significant interference levels. Record on the data sheet the interference levels at least three frequencies per tuning band.

5. Repeat this procedure for each power line in the distribution box.

4.3 Operational Sequence of On-Board Equipment

With the cooperation of the radio operator and other members of the ships crew an effort will be made to identify sources of on-board interference by scheduling the operation of each equipment which is a possible interference source. This will include electrical equipment such as winches and hoists as well as communications/electronics equipments such as radars and MF, HF, and BHF communications gear. This scheduling will be contingent on the ship's operational requirements and may not be convenient at all times. A best effort attempt will be made.

5.0 Test Instrumentation

5.1 List of Equipment

5.1 Equipment Supplied by RCA Service Company

(1) Singer Stoddart NM-25T Radio Interference and Field Intensity Analyzer, 150 kHz to 32 MHz.

(2) Singer Stoddart RF Current Probe, 150 kHz to 190 MHz.

(3) Singer Stoddart RF Cable, 20 feet.

(4) AIL Type 2392A Radiometer

(5) Bird, Model 74 Coaxial Switch

(6) Narda, 50 ohm, 5 watt, Model 370 NM Load

(7) Hewlett Packard Model 614A Signal Generator, 800 to 2100 MHz.

5.1.2 Equipment Leased from Electro-Rents Inc.

(1) Singer Stoddart NM-65T Radio Interference Analyzer, 1 to 10 GHz.

(2) Singer Stoddart Headphones

(3) Singer Stoddart Video Cable (2) for X and Y outputs.

5.1.3 Equipment Leased from Rental Electronics, Inc.

(1) Singer Stoddart, Horn Antenna, Band 1 (1.0 to 2.3 GHz).

(2) Singer Stoddart, Horn Antenna, Band 2 (2.0 to 4.4 GHz)

(3) Singer Stoddart, Horn Antenna, Band 3 (4.4 to 7.3 GHz)

(4) Singer Stoddart, Horn Antenna Band 3
(4.4 to 7.3 GHz)

(5) Singer Stoddart, Mounting Adapter for Band 1
and 2 Horns.

(6) Singer Stoddart, Antenna Reflector for Band 3 Horns

(7) Singer Stoddart, Tripod and Pan Tilt Head for
Antenna.

(8) Hewlett Packard Model 7034A X-Y Recorder

(9) Singert Stoddart, ANtenna, Conical Log Spiral
with Mast

5.1.4 Equipment Supplied by Applied Information Industry (AII)

(1) Antenna, 4 foot reflector and circularly polarized
feed for ship terminal

(2) TACO Tripod Mount for 4 foot antenna reflector
with counterweights

(3) L-Band Diplexer, receive frequency, 1559.0 MHz;
Transmit frequency. 1659 MHz, Insertion loss 0.5 dB;
Bandwidth 20 MHz; Isolation 90 dB between transmit
and receive ports.

(4) L-Band Low Noise Amplifier (LNA), 1535 to 1562 MHz;
Noise Figure approximately 3 dB, 30 dB gain; One dB gain
compression point, -20 dBm input.

(5) L-Band Down Converter, Converts 1550 MHz input frequency to 50 MHz IF Center Frequency, RF passband bandwidth is ± 3 MHz at 3 dB points; 30 dB gain at center frequency; Output noise level, -55 dBm (50 ohm).

(6) Local - oscillator frequency synthesizer module and power supplies.

(7) Coaxial Cable, 7/8 inch low loss foam dielectric, 40 feet

(8) Microwave Filter, Diplexer to Antenna, 0.2 dB insertion loss 1535-1660 MHz; 60 dB rejection above 2.9 GHz.

(9) Microwave Filter, LNA to Diplexer, 0.2 dB insertion loss 1535-1660 MHz, 60 dB rejection above 2.9 GHz.

(10) Microwave Filter, transmitter to Diplexer, 0.2 dB insertion loss 1635-1662 MHz; 60 dB rejection above 2.9 GHz.

5.1.5 Equipment Supplied by NASA, GSFC

(1) AIL Model 124 Power Oscillator, 15 watts output.

(2) Cold Reference Load, 50 ohms, 77°K

(3) Hot Reference Load, 50 ohms

(4) HP Model 141-T Spectrum Analyzer - Display Section

(5) HP Model 8555A Spectrum Analyzer - Tuning Section

5.2 Bandwidth Selection and Adjustment

The Singer Stoddart NM-65T Radio Interference Analyzer has a selection of three bandwidths, 0.1, 0.5, and 5 MHz. The greatest narrowband sensitivity is achieved with the 0.1 MHz bandwidth while the greatest broadband sensitivity is obtained with the 5MHz bandwidth. Field intensity measurements will be made initially with NM-65T bandwidth set at 0.1 MHz and while it is scanned from 1 to 10GHz. All narrowband signals within the limit of the sensitivity will be displayed on the X-Y Chart. If there is evidence of broadband signals which should be investigated, a second run will be made with the bandwidth set at 5MHz.

In-band measurements (1535 to 1660MHz) will be made with the bandwidth set at 0.1 MHz for maximum detail in the band. When maximum narrowband sensitivity is not required as for the field intensity measurements in the storage room and the conducted interference measurements, the 5MHz bandwidth will be used.

5.3 Scanning Speed

Scanning will be done manually and can be set at any desired speed. The speed of scanning must be consistent with the response of the instrument and its frequency accuracy. The frequency accuracy of the NM-65T is $\pm 2\%$ of the indicated dial frequency. With a tuning range of 1 to 10GHz or a ratio of 10 to 1 the number of frequency accuracy increments in the tuning range is:

$$(1 + .02)^n f_o = 10 f_o$$

$$\text{or} \quad n = \frac{\log 10\ (10)}{\log 10\ (1.02)} = \frac{1}{.0086} = 116$$

Thus the X scale on the graph paper which is 10 inches is divided into 116 increments to be consistent with the 2% accuracy of the tuning dial.

A requirement also exists for the time, t_a, of a scanning receiver to cover one of these accuracy increments. It must not be shorter than, t_p, the time it takes the X-Y plotter to come up to a full scale Y-axis scale signal response and return to the zero position. Hence, $t_a \geq t_p$. Since the writing speed of the HP-7034A is 30 inches per second, and since the useful Y-axis dimension of the chart paper is 7.5 inches it takes about 0.5 seconds to write up and down full scale. Since the 2% increments each require 0.5 second dwell time, the minimum scan time is equal to half the number of increments in seconds or 58 seconds to scan from 1 to 10 GHz. Choice of a lesser time will result in a poorer frequency accuracy and structured responses would tend to merge together. Conversely, a longer scan time is a waste of time since it will not result in improved data.

An other consideration is the matter of accuracy versus resolution. Ordinarily the resolution is determined by the RF window (IF bandwidth). The bandwidth of the NM-65T can be adjusted between 0.1 and 5 MHz. Thus in the 1 to 10 GHz band there are 90,000 bandwidths for the 0.1 MHz IF bandwidth or 1,800 bandwidths for the 5 MHz IF bandwidth. In either case, the resolution is much greater than the frequency accuracy and does not govern the scanning rate.

6.0 Preparation of Conclusions and Recommendations

During the tests in harbor, and at sea, efforts will be made to identify interference sources that are on board the ship as well as those that are external to the ship. Their direction will be determined, in azimuth/elevation angle, or referenced to a known point on the ship. With the cooperation of the ships crew it will be possible to turn various communications and electrical equipment on and off as a method of identifying interference sources. External sources may be identified by their operating frequency, harmonic structure, repetition rate of modulation and other characteristics. The AN/SPG-29 search and rescue radar has been identified as an interference source to the L-band terminal. This type radar is used by the Coast Guard, and Navy, and a watch will be kept for this interference in harbor.

The conclusions and recommendations will also discuss possible interference mitigation and suppression measures where on board equipment may be responsible for interference to the proposed L-band terminal. If there are areas of investigation that have not been fully explored, or which could not be attended to in this test, a suggested follow-on plan will be discussed in the test report.

7.0 Format of Test Report

A standard test report format will be used. MIL-STD-831, while not binding on this contract, will be used as a guide for the preparation of the test report.

7.1 Outline of Test Report.

I. Administrative Data

II. Appendices

III. Report on Measurements

  A. Description of Test Locations

  B. Identification of Measuring Instrumentation

  C. Calibration Information

  D. Description of Test Procedures

  E. Application of Filters

  F. Indentification of Interference Sources

  G. Selection of Test Frequencies

  H. Antenna Factors and Current Probe Transfer Impedance

  I. Sample Calculations

  J. Graphs of Field Intensity Versus Frequency

  K. Photographs of Test Setup

  L. Special Terms and Abreviations

IV. Recommendations and Conclusions

Appendix A - EMI Tests of L-Band Shipboard Terminal

Appendix B - Field Intensity Measurements

Appendix C - Antenna Sky Temperature Measurements

Appendix D - Conducted Interference Measurements

Appendix E - Interference to Radar Observations